THE COASTAL ZONE
FROM
ICY BAY TO CAPE SUCKLING

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INTRODUCTION

Background

In the Gulf of Alaska, research of coastal marine and terrestrial environs has largely centered around potential resources development and the impact such a development may have on the total environment. The affects of forest clear cutting, unnatural damming of rivers and streams and the potential hazards of offshore oil drilling and heavy exploitation of commercial fish are well known examples.

Studies in the north Gulf dealing with these problems have been conducted by a number of agencies. The Bureau of Land Management (1975) prepared an extensive monograph on the main physical and biological features of the north Gulf. In 1972, the Institute of Marine Science compiled a series of investigations dealing with a number of environmental and ecological aspects of the Gulf of Alaska. Presently the Alaska Department of Fish and Game is compiling distributions and occurances of principle terrestrial and marine faunas for publication in a comprehensive atlas. Such studies are the first steps toward a comprehensive coastal zone management program.

Literature dealing directly with overall environmental/biological interaction and entire coastal ecosystems in Alaska is wanting and only one fairly comprehensive study of a specific coastal environment has been completed. The Environment of the Cape Thompson Region, Alaska (1966).

Purpose and Objective

The overall objective of this document is to define the environmental and ecological processes which delineate the coastal zone between Icy Bay and Cape Suckling.

With this in mind, the specific goals are: 1.) to define and emphasize the importance of each aspect of the coastal zone, 2.) to give an accurate description

of environmental conditions in the northeast Gulf, 3.) to describe the environmental and biological relationships that exist there, and 4.) define and stress the most important aspect of the coastal zone.

THE COASTAL ZONE

The coastal zone can be defined as all environmental and biological processes occurring in relation to the land-sea interface. In particular, it is the zone bounded by a transition, that separates processes that are either strictly marine or terrestrial (Figure 1).

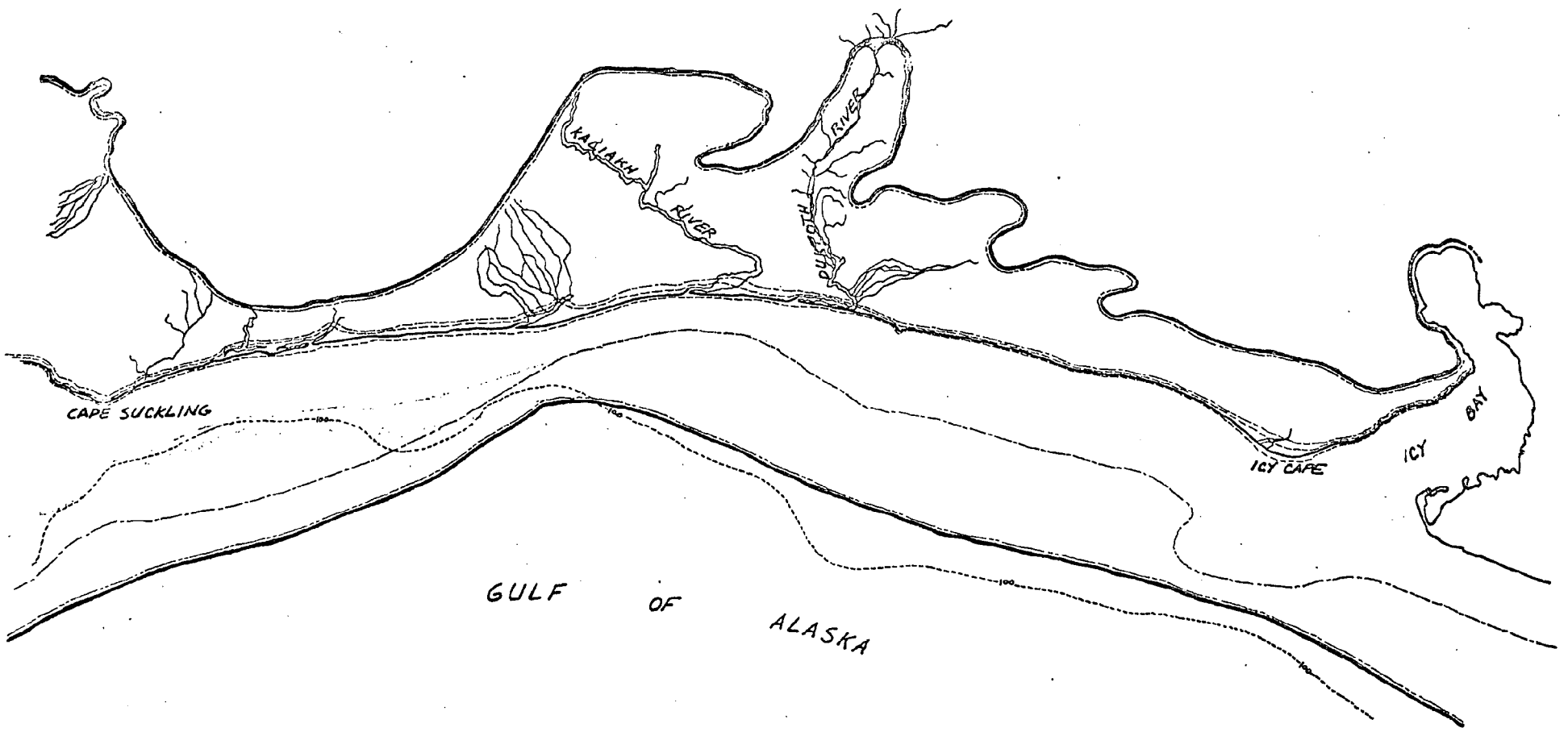
The coastal zone can be delineated by certain environmental and ecological boundaries. These boundaries define three areas or sub-zones, namely: the zones of indirect influence, direct influence, and direct interaction. The biological and physical features of each are largely the result of geological and climatic occurences taking place over time. Further, these features can be integrated into an ecosystem peculiar to each sub-zone.

The zone of direct interaction is that area of high dynamic activity. There, features are in a constant state of change. Physical associations are tides, waves, sediment transport and the seemingly ever changing rocky and sandy beaches. Biological associations comprise organisms adapted or affected by such conditions (e.g. sandpipers, clams, barnacles, annelids, and certain marine algae) some of which could possibly not survive elsewhere.

An extension of the direct interaction zone is the zone of direct influence. Here, physical features are less dynamic, but influence on a biological scale is very recognizable. Some characteristic land-sea interactions are: saltwater and salt spray influencing vegetation adjacent to the beach and alluvium and freshwater from inland streams influencing the receiving marine waters in the nearshore area. Terrestrial mammals and birds all utilize this area in varying degrees.

Environmental/biological activity beyond these sub-zones results in sub-zone of indirect influence. This area essentially encompasses the entire coastal zone, since land-sea interactions, though "remote" are involved. It includes all biological

FIGURE 1: Coastal zone from Icy Bay to Cape Suckling showing approximate environmental/biological land-sea interaction boundaries.



and physical activities which could be influenced by "outside" mechanical activities (dam construction, forest harvesting activities, commercial exploitation of fish etc.).

Interaction of these sub-zones results in the coastal zone which in turn represents the transition between purely marine and terrestrial environments. The coastal zone as it occurs in the north Gulf of Alaska, in itself is a unique and separate ecosystem.

Following is a brief description of environmental physical and biological activities occurring there.

COASTAL AND NORTH GULF CLIMATOLOGY

General climatic conditions in the north Gulf and along the coast are detected by a combination of meteorlogical and physical features. Two seasonal barometric pressure systems, the Aleutian Low and North Pacific High, prevail in the north Gulf. These lows and highs which affect precipitation and temperature are reinforced and buffered by certain terrestrial (e.g. coastal mountains) and marine (e.g. currents) features. The result is a maritime climate with relatively moderate winters and cool summers. Precipitation is considered high during both the winter and summer months. Gusting winds (> 65 KPH) are frequent during winter (Rosenberg, 1972; BLM/AOCS, 1975; APG, 1973). A summary of temperature, precipitation and winds at Yakataga are listed in Table 1.

Table 1: Range of Climatic Factors at Yakataga, Alaska
Searby, 1969)

Temperature Range:

Summer: 5.5° to 16.6° C
Winter: -5.5° to 4.4° C
Extremes: -23.8°C and 25.5°C

Precipitation

* 261.6 cm includes 276.9 cm of snow

Wind Velocity Range

Average: ESE at 11.5 kph
**Extremes: 48.3 to 80.5 kph

*measured as water
**occasionally to 112.6 kph

Abundant moisture, high humidity and cool to moderate temperatures provide a favorable climate for the growth of certain types of climax vegetation. In this section of the north Gulf these conditions have produced the coastal Sitka spruce-western hemlock forest system and its associates (Smith, 1966).

DESCRIPTION OF GULF AND COASTAL ZONE WATERS

Physical and Chemical Parameters Affecting Marine Biotic Communities

Marine Geomorphology - Morphological features of the northern Gulf of Alaska continental shelf and shelf edge may be the result of glaciations (the Naptown) occurring during the late Pleistocene (Noonan, Marathon Oil Company, personal communication, 1975). Submerged troughs, sea valleys, ridges and rock out-crops are evidence of that period.

Overlapping many of the shelf features are matraces of unconsolidated Halocene and possibly late Pleistocene deposits (Plafker, 1974). These sediments probably originated from retreating glaciers during those periods (Wright, et al in preparation; Moiseev, 1963).

The fate of these sediments is governed by gulf currents flowing from the southeast to the northwest (Wright et al in preparation). Moiseev (1963) found that at topographically high areas all but the coarsest sediments were swept away and at still others rock out-crops occurred. Wright and Valencia (1968) and U.S. Geological Survey sources (1975) have proposed simple and detailed distributions of these sediments.

The most typical sediment in the northeast Gulf is a fine, gray-colored mud. Moiseev, (1963), Wright and Sharma (in press) seem to agree on this point. Moiseev describes it as pelite (particles less than .01 mm) and comprising 40-70% of all material. Further, Moiseev (1963) feels that mineral particles found in these sediments are the result of river systems draining glaciated areas, rather than of the past glaciations themselves.

Wright and Sharma concluded that the muds (pelite) of the region are poorly sorted and contain particulate materials often in a large range of granulometric categories. In particular, fine sand is common, with very occasional coarser pebbles (Wright and Sharma, in press). Moiseev (1963) goes into a somewhat detailed description of the distribution and classification of northern Gulf sediments. He

describes the area as follows:

> "... Less coarse sediments are found on banks and adjacent bottom rises in the east of Kodiak-Kenai and in the Yakatat subregions of the shelf zone, since fine material of glacial orgin forms one of the major components everywhere in these sediments. Therefore, heavily muddied sediments sometimes with an admixture of pebble, gravel and shell are common here. Large areas are occupied by mud and clayey mud which occur even on bottom rises. Sediments on plateaulike shelf areas become somewhat less muddy ...Fine sediments (sandy mud, mud, and clayey mud) of considerable thickness occur in sea valleys and troughs; both traverse and parallel to the shelf trend. Sediments on the sides of the depressions are more muddied than those on subsided parts of level shelf surfaces" (Moiseev, 1963).

On the shelf edge Moiseev (1963) views the sedimentary cover as generally monotonous, exhibiting little variation with contents consisting of pebbly-graveled material sometimes approximating sands and clays

Benthic sediments provide a number of niches unique to certain groups of marine flora and fauna species. In this section of the coastal zone these niches support organisms adapted for mobile filter feeding.

Chemical and Physical Nature of Marine Waters - Geostrophic currents for the Gulf of Alaska have been calculated from temperature, chlorinity and depth of water sample datum by early and recent researchers (McEven, et al, 1930; Thompson, et al, 1936; Favorite, 1970; and Royer, 1974). Calculations show a general counter clockwise flow of 10cm/sec with a nearshore flow of approximately 9cm/sec (Muench, 1974).

Sediment transport along the coast is in a northwesterly direction up to Kayak Island, at this point the direction reverses and the transport is southwesterly (Sharma in press). A complex of down-welling in winter and up-wellings in summer complicate the transport mechanisms.

Turbidity in the north Gulf is most noticeable in nearhsore waters during summer months when high amounts of glacial meltwater enter the sea directly (Sharma, et al, 1974).

Tides and waves caused by north pacific storms range between 2-4 meters and 3-4 meters respectively (AEIDC/ISEGR, 1974; GAOC, 1973).

Distribution and abundance of available nutrients (silica, phosphate and nitrate) trace elements (e.g. Mg, Zn, Fe, and B) and dissolved oxygen levels are at saturation in the upper 100 meters of Gulf waters. Nutrient distribution correlates closely to isotherm configuration during winter months, while during summer their distribution is more random as a result of greater biological activity (Longerick and Hood, 1972).

Like benthic features, both physical and chemical factors of the marine environment no doubt play major roles in the fate and habits of a majority of benthic, pelagic and nearshore biotic communities.

In the area between Icy Bay and Cape Suckling the intertidal zone is sandy and few large rock out-crops are present. The bottom composition is the result of transport from marine current actions and alluvian (glacial) from coastal rivers. Thus, the resulting plant and animal communities there are made up of unattaching forms.

Marine Biotic Communities in and Near the Coastal Zone

Marine vegetation (algae and phytoplankton) - Unfortunately, little work has been done in the way of marine vegetation studies for the region between Icy Bay and Cape Suckling. Though the area in question has no recorded collections and is generally sandy and wave beaten (BLM/AOCS, 1975). Scagel (1963) indicates that nearshore waters can and probably do support a few species of attaching algae (e.g. kelps). A micro flora, between grains of beach sand and attached to gravel and cobble rock surfaces, probably lies in the intertidal zone (BLM/AOCS, 1975).

The only comprehensive vegetation surveys in the study area are those on phytoplankton distribution. This floating plant community consists of marine diatoms and dinoflagellates (BLM/AOCS, 1975). An indication of phytoplankton distribution can be obtained by measurement of photosynthetic activity or primary production, which is the fixing of organic nutrients and carbon by light energy. Studies of phytoplankton activity in nearshore waters and estuaries of the Valdez, Alaska area indicate an

annual productivity of 200 gC/m^2/year. This figure indicates significantly higher production than the continental shelf which only produces 150 gC/m^2/year.

Primary production is a seasonal occurence and declines drastically during winter months (Goering et al, 1973). It also can decline in summer months, but this normally occurs only where affluent rivers enter the Gulf (BLM/AOCS, 1975).

The importance of marine vegetation and marine phytoplankton lies in their potential as a base source of energy (in organic form) in the marine food chain (BLM/AOCS, 1975).

Marine Invertebrates (zooplankton and micronekton) - Like phytoplankton, only a small amount of work has been conducted with respect to the nature of zooplankton in the north Gulf. Knowledge of zooplankton activity there is largely inferred from other areas (BLM/AOCS, 1975).

Zooplankton are assembleges of heterotrophic organisms smaller than 10 mm in length. They are limited in swimming ability and are mostly herbivorous copepod species (sometimes making up 90% of the total biomass) with varying stocks of euphausiid, amphipods, decopods, chaetognaths, pterpods and small cephalopods (BLM/AOCS, 1975; LeBrasseur, 1965).

In general coastal zooplankton populations correlate closely with phytoplankton peaks and lulls. It has been suggested (BLM/AOCS, 1975) that maximum zooplankton populations lag a month or two behind well defined spring blooms of phytoplankton in nearshore waters. Such is not the case, however, in the open Gulf. There, no spring blooms of phytoplanktonic organisms are apparent since grazing juvenile copepods have already migrated to the scene and consumed them (Parson and de Lange Boom, 1974). Cooney (1972) found few migrating juvenile copepods with the exception of Calanus pacificus, on the continental shelf; thus with insufficient grazers present spring blooms of phytoplankton occur there (Larrance, 1971; McAllister et al, 1960).

The amount of organic carbon transferred in coastal areas has been estimated by Gulland (1972). Using a estimate of 150 gC/m^2/year for primary production and a

transfer efficiency, of fifteen percent, Gulland estimated the rate of zooplankton herbivore production at 22 gC/m^2/year. Vinogradov (1968) feels that such a transfer is part of the mechanism by which synthesized organic matter is carried from the surface to depth.

Micronekton are also heterotrophic organisms, but because of their stronger swimming abilities and size (10-100 mm) they are not considered planktonic. Members of this group include: euphasidds, mysidds, pelagic shrimps, cephalopods, fish, larvae and small fish. Not much is known of micronekton distribution and abundance (Cooney, 1972). It is known, however, that certain members are major food items for many near surface and deep feeding pelagics (e.g. euphasidds are the major food for whales, herring, cod, pollock, and salmon (Cooney, 1972).

It should be apparent that zooplankton and micronekton play a major role in the transfer of organic carbon and other nutrients up the food chain in the vast marine ecosystem and the coastal zone. As Gulland (1972) suggests, fifteen percent of the the organic carbon synthesized by phytoplankton in coastal waters reappears in zooplankton biomass. A percentage of this (zooplankton herbivore production) in turn is utilized by a variety of bottom and near surface feeders.

Benthic trophic groups - Four trophic groups utilize the benthic habitat in the north Gulf. Classed according to their method of feeding they are: seston feeders, browsers and nonselective consumers (detritus feeders) and scavengers and carnivores (Moiseev, 1963). Seston feeders as the name implies, filter bits of decaying matter and minute living organisms from the water and include: clams, scallops, barnacles, sea pens, and some polychaete worms. The detritus feeding group is made up of several gastropods, protobranchs, polychaetes, ophiuroids, and halothuroids which feed mainly on decomposed or decomposing organic matter. Browsers, many of which are protobranchs and polychaetes, sort detritus to a certain extent, while nonselective consumers, mainly polychaetes, have no selective tendencies. Scavengers and carnivores feed on carrion or capture their prey alive. Crabs, shrimps, and snails are members of this group (BLM/AOCS, 1975).

All four groups are affected by the distribution of shelf sediment and its components. Filter feeding organisms concentrate on banks and the sides of troughs and canyons where particulate suspension is high. Detritus feeders (both browsers and consumers) prefer sandy bottoms (Moiseev, 1963).

In the north Gulf, the shelf and shelf edge are covered mostly by silty sands and muds. Hard bottoms are very limited. Because of this, the region is dominated by the detritus feeding groups (both consumer and browser) with the filter feeding group only contributing 10.5% of the total biomass. Scavengers and carnivores comprise 9.4% of the total (Moiseev, 1963). Note that these figures are not specific to the area between Icy Bay and Cape Suckling, but represent data taken from the whole of the north Gulf (including the Prince William Sound area).

Alaska Department of Fish and Game has determined that the commercially important weathervane scallop (Patinopecten caurinus) occurs in high density between Icy Bay and Cape Suckling. These scallops are most abundant between 55-128 meters and represent one of the highest concentrations in the north Gulf. Spawning takes place but once a year, occurring during June through mid-July. Larvae are planktonic before settling to the substrate where they assume an adult form in a few months.

While this discussion has so far been concerned with those substrates which are constantly covered by marine waters of and near the coastal zone, the following shall be concerned with those of the intertidal area (region between high and low tide) entirely within the coastal zone.

As previously mentioned the subtidal and upper continental shelf areas between Icy Bay and Cape Suckling are predominently sandy, pebbly, and muddy with an occasional rocky area. The intertidal zone is very similar. There the fauna consists of burrowing shrimps and small crabs in the high intertidal sandy muds, and worms, snails and crabs common in the middle zone. The lower intertidal zone is more diverse and contains snails, slugs, nudibranches, worms, and clams (Richetts, Calvin and Hedgpeth, 1968). On the beach proper, the fauna above high tide consists mainly

of crabs and [illegible] ... middle and low tides occur and clams can usually be found restricted to the lower tide areas (BLM/AOCS, 1975).

Many of these subtidal and intertidal organisms (include seston and detritus feeders as well as benthic carnivores and scavengers) fall prey to animals still higher in the marine food web (e.g. estuarine, and anadromous fish and certain marine mammals) which subsequently utilize coastal land masses during parts of their life history. Thus, benthic invertebrates are important to the coastal zone as transferrers of organically fixed energy energy to adjacent coastal land masses.

Marine Mammals (from coastal zone boundary to open Gulf) - A number of cetaceans pass through the north Gulf on winter and summer migrations. These mammals are fish like and composed of both toothed and baleen species. Little is known of their habits, except for some information on migrating and feeding activites. When feeding, baleen members siphen water to extract food which consists of benthic invertebrates, euphasiids, copepods, and small fish. Toothed whales feed on a variety of fish and molluscs especially squid and octopus. Some feed on pinnepeds and seabirds (BLM/AOCS, 1975).

One notable mammal of the north Gulf is the northern fur seal (Callorhinus ursinus). This mammal migrates through the area and mature males are seasonal residents occurring in an area (16-145 kilometers offshore). They do not haul out unless injured or sick. Food consists of a variety of fish (e.g. herring, pollock, capelin, and sand lance, and especially squid). They are very active during morning and evening since some important food species are in the uppers layers during darkness (Wilke, 1960).

Marine Mammals (from coastal zone boundary into shore) - Few species of cetaceans are found in the nearshore waters between Icy Bay and Cpae Suckling, however, the Dall and harbor porpoise (Phocoenoides dalli and (Phocoena phocoena) (BLM/AOCS, 1975) may be found there occasionally. Dall porpoise feed on squid, fish (saury, hake, herring jack mackeral and bathypelagic and deep water benthic fish) (USDC, 1973). Harbor porpoise frequent sheltered bays and mouths of large rivers (BLM/AOCS, 1975). The feed primarily

on bottom fishes such as cod, herring fry, flounder, and occasionally on invertebrates such as squid, clams and crustaceans (USDC, 1973).

Other marine mammals that occur along the coast are the harbor seal (Phoca vitulina richordi) and the steller sea lion (Eumetopias jubata). Harbor seals occupy both clear and turbid waters, preferring sheltered areas. An important concentration occurs at Icy Bay, with minor ones at the mouth of the larger rivers. Icy Bay, in particular, provides hauling out and pupping areas (ice pans) in addition to preferred food stuffs. Food is composed of a variety of organisms which consists mainly of crustaceans, squid, octopus, and fish such as herring, flounder, eulachon, salmon, rock fish, cod and sculpin (Calkins, Pitcher and Schneider, 1975; Pitcher, 1975).

Whereas harbor seals occur close to shore, sea lions are somewhat more pelagic. They prefer exposed waters in summer and sheltered areas in winter. Sea lions normally remain nearshore but can be sometimes found far offshore. Food is primarily schooling fish, but rock fish, pollock, flounder, etc., are also eaten. No important rookeries occur in the area from Icy Bay to Cape Suckling (Pitcher, 1975, Pitcher, ADF&G, personal communication, 1975).

Except for harbor seals, marine mammals are probably not an important group in the coastal ecosystem between Icy Bay and Cape Suckling. Because of the large breeding concentration of harbor seals at Icy Bay the area of the coastal zone is probably very important in the survival of that species. Any activity which would have an effect on the availability of prey organisms, or critical habitat areas (Icy Bay) would have a detrimental effect on marine mammals along this area of the Alaskan Coast.

Coastal and North Gulf Fish - Fish of the north Gulf and coast can, to a certain extent, be grouped by certain general habits peculiar to them. In Gulf waters there are the near bottom or demersal and near surface pelagic fishes. In near coastal waters (includes both estuaries and terrestrial streams) they can be grouped as nearshore, anadromous and freshwater. All at one time or another depend heavily on marine, estuarine or freshwater invertebrates.

Demersal fish on the upper continental shelf and in coastal zone waters are principally flounders (Pleuronectidae) and cods (Gadidae), but a host of smaller forage fishes may also be encountered and include a host of osmerids (smelts), pholids (gunnels), and cottids (sculpins). These fishes feed heavily on zooplankton, euphausiids, and copepods (Alverson, 1975). Near surface pelagics especially mature salmon (Salmonidae) feed on a variety of organisms ranging from zooplankton to other fish.

Nearshore members, notably pacific herring (Clupea harengus pallasi) and capelin (Mallotus villsus) spawn and feed in coastal zone waters, Planktonic invertebrates and fish larvae are the main food items of these species.

Strictly freshwater and anadromous species include sticklebacks, Gasterosteidae; some sculpin, Cottidae; and salmon (anadromous), Salmonidae. These fish feed on adult aquatic insects and their larvae during juvenile and/or adult stages (Hart, 1973).

Of the families mentioned, most are familiar and some are of commercial value. They should by no means be considered wholly representitive of the fish found in any one local environment. There are of course many more species.

Though the coastal zone from Icy Bay to Cape Suckling supports a number of fish species and is critical to the life histories of some (e.g. salmonids, clupeids, and some osmerids) it rears only one species approaching significantly large numbers - the coho salmon (Oncorhtnchus kisutch). In past years Brogol (ADF&G, personal communication, 1975) has found this species to be present in almost every stream surveyed with total counts numbering in the several thousands (10 year total). It is felt that this species, which is preyed on by bears and by some scavenging birds, is one of the main biological food/energy links to the land in the coastal zone food web.

DESCRIPTION OF TERRESTRIAL COASTAL ZONE AREAS

Physical and Chemical Parameters Affecting Terrestrial and Biotic Communities

Terrestrial Geomorphology - Terrestrial geology in the north Gulf has been researched rather thoroughly in connection with oil resource development there.

Deposition of northern Gulf terrestrial features began in the early Cenozoic with the development of four recognizable rock formations of entirely clastic sedimentary and volcanic rock and of Tertiary age (Plafker, 1974). Overlaying these in part are recent formations comprising of Holocene sand, gravel, mud, and fill deposits of mid Quaternary age and all the result of depositions by sea, stream and glacial mechanisms (Plafker, 1974).

The resulting scene is one of a rather continuous plain backed by mountains of high relief. The region as a whole clearly reflects both tectonic and glacial influences (Wright, 1972). All along the crest of the Robinson Mountain Range are rather large glacial formations. The coastal plain too, is dominated by some of these same glaciers, namely the Bering Glacier (Wright, 1972). As a result, numerous small drainages braid the region, all flowing seaward and into the Gulf directly.

The coastal proper has also been modified by glacial mechanisms. Large fiord-like bays (Icy Bay) have been exposed. Receeding glaciers have left these inlet-estuarine systems cutting far into the coastline and often with depths greater than those of the adjacent continental shelf (Wright, 1972).

Coastal features, either singly, or in combination, provide unique habitats for both plant and animal life. Consequently, a rather recognizable distribution of different communities occurs all along this section of the north Gulf coast.

Chemical and Physical Nature of Terrestrial Soils - Along the north Gulf coast surficial deposits range from well-drained rather dark and acid soils to poorly-drained glacial outwash. Well drained stratified materials on floodplains and low terraces also

occur (APG, 1973). All are either alluvial, glacial, lacustrine, or beach deposits of Quaternary age (Plafker, 1974). Permafrost indications along the coast are negligable (APG, 1973).

Specific soil conditions in the north Gulf largely compare with those surveyed for the Hollis Alaska (72 kilometers northwest of Ketchikan. There soil difference can be observed in an elevation sequence. Most have been transported with the exception of organic soils which develop in place from restricted drainage (bogs) and some alpine soils (Stevens, 1963). Alluvial and glacial deposits form the parent material in the lower valleys while alluvial deposits provide the base at middle elevation (Stevens, 1963).

Soils are rather shallow and of medium texture and have thick litter layers where vegetation is firmly established. Other soils contain large percentages of gravel and stone, except for organic and some alpine soils (Stevens, 1963).

Most of the soils of the Hollis area are acidic and have a pH range of 3.4 to 5.0 for surface soils and 6.0 for the subsoils. Analysis of thick surface litters also show high nutrient levels including those most utilized by the plants. These litter layers further show a cation-exchange capacity of 40 to 140 mv per 100 g. The percent base saturation for these same soils ranged from approximately 7 to 32.

No doubt soil conditions, coupled with local temperature gradients, are the controlling factors of soil communities (Stevens, 1963). Depending on local aerobic, acidic, organic and thermal conditions, these soil communities (invertebrates and decomposing fungi) will vary and in turn influence higher plant and animal community structures.

Though the soil profiles which have been studied are local to Hollis, Alaska, researchers have shown that they may be the norm throughout southeast Alaska (Stevens, 1963).

Terrestrial Biotic Communities in and near the Coastal Zone

Terrestrial Vegetation - Stevens (1963) determined in southeast Alaska, (Hollis area)

that plant communities can be related to soil type with some accuracy. Further studies also showed that associations, as with soils, occur along an elevation gradient. Component soil groups along the gradient (increasing from sea level to 914 meters) are: alluvial soil, Ragosoils, Podzol-Bog, Podzol Lithosal, alpine soil, rock outcrops (Stevens, 1963).

Similar plant/soil community association can be drawn for the north Gulf since the soil sequence is generally the same throughout the southeast (Stevens, 1963).

For simplicity's sake, tidal flats, delta land, and flood plains are all grouped in the alluvial soils. It should be noted that tidal flat soils are not wholly the result of alluvian transport. The soils of all these areas are associated with large quantities of salt or freshwater at sometime or another. Thus, vegetation types in these areas must tolerate salt or freshwater intrusions. The salt marsh habitat is a prime example for display of these types.

The Ragosoil group represents a ribbon extending from the wave swept beach inland to an elevation of approximately 45 meters. In the north Gulf from Cape Suckling to Cape Yakataga (glacial region), this association extends inland for some distance. From Cape Yakataga to a point nearing Icy Cape the association becomes a narrow band only to broaden again at the Icy Cape proper. Along Icy Bay the association seems to narrow drastically. The soils of the Ragosoil group are somewhat moist and pioneering vegetation (hardwoods) abounds. On better drained soils conifers have taken hold. Along the beach proper, salt spray no doubt has its effect on adjacent vegetation.

The Podzol-Bog group is represented by soils with climax forest communities. The soils are generally better drained due to the steepness of the terrain. The association is western Hemlock-sitka spruce. Depending on soil condition, hardwoods may occur. Woody plants may disappear entirely in restricted drainage areas (bogs). The Podzol-Bog group extends to approximately 457 meters. In Hollis, Alaska, at about 215 meters, vegetation in the Podzol-Bog group begins to transcend from a western Hemlock-Sitka spruce association to a somewhat different type. At the 760 meter level, the transition is complete and mountain hemlock is firmly established. The soils there

are shallow and slopes are rather steep (Stevens, 1963).

Again in the Hollis area, above approximately 610 meters an alpine association begins to appear. The soils are only moderately drained and become rather highly acidic and dark. The terrain at this level does not change abruptly and the area is considered to be an ecotone between sub-alpine and strictly alpine environments. Grasses, sedges and mosses occur frequently along with a few wind-blown conifers (Stevens, 1963).

Above this group in the north Gulf, a strictly alpine association probably occurs in some areas. Vegetation at these elevations are almost wholly tundra types. Barren rock outcrops with little or no soil occur only at the highest elevations.

It should be apparent from the above treatment that vegetative communities are not only dictated by soil type and drainage. Stevens (1963) indicates that associations are further influenced by major conditions such as local geomorphic and climatic conditions. Further, as these vegetative and geomorphic conditions change apparently so do the animals using them. This is evident in mammal and avifauna distributions published by the Alaska Department of Fish and Game (1975).

Terrestrial and Freshwater Invertebrates - Four groups of invertebrates dominate the north Gulf coastal zone, these include: aschelminth phyla, annelids, arthropods and the protozoas. Though few studies concerning any of these groups have been undertaken, members representing them no doubt occur (BLM/AOCS, 1975). Aschelminths (nematodes, rotifers, etc.) are most familiar from an aquatic or parasitic standpoint, but some free living forms do inhabit the soils. Protozoans and annelids also occur in both soils and in aquatic situations.

Arthropods are probably the most noticeable group and include spiders, mites, isopods, insects, and many more to numerous to list here. Members of this phylum probably have invaded all habitats of the coastal zone from salt marshes to freshwater streams to terrestrial soils and vegetation (BLM/AOCS, 1975).

As a whole, most members of these phyla are important to the coastal ecosystem. Some cultivate and "nourish" the soil while others, especially insects, provide food for the terrestrial birds, mammals and fish. Elliott, (personal communication, 1975) feels that upwards to 90% of the intake by juvenile fish in coastal streams between April and November is composed of these (insects) arthropods.

Terrestrial Mammals (lowland) - The general conditions of the glacial outwash plains afford a variety of habitats suitable for terrestrial mammals. Conditions (local climate and topography) there tend to dictate the type of vegetation and consequently the mammal distribution. Only in isolated places does the elevation of vegetated lowland areas exceed 60 meters (Suckling Hills) thus, the area takes on the characteristics of locally moderate climatic conditions. In general soil habitats are moist to wet with pioneering vegetation, predominately (willows, alders, cottonwood, etc.). Notable mammals utilizing the area are moose, black and brown bear. Lesser mammals include lynx, hare, and beaver to name a few. Numerous microtine (shrews, voles and mice) populations inhabit grasses and shrubs there feeding heavily on invertebrates and the local vegetation there.

Depending on the time of year, local mammal distributions vary and are largely dictated by the availability of seasonal foods and shelter (e.g. bears feed along salmon runs in fall and den in locations that are rather rocky and high in winter).

Terrestrial Mammals (Mountain) - The mountain regions have a somewhat different mammal population. Here elevations range to 1065 meters and the vegetation type is climax forest (coniferous) and alpine tundra. Notable mammals include the brown and black bear. There is, however, a general absence of moose and beaver resulting from a scarcity of preferred foodstuffs (especially alder and willows). Furbearers occurring are pine martin and wolverine. Red squirrels also become frequent since spruce cones are their preferred food. Other mammals not generally found in the glacial outwash area are

pike, marmots, and mountain goats all of which prefer rocky and tundra areas (ADF&G, 1973; Michelson, personal communication, 1975).

As was previously mentioned topography and vegetation tend to distribute mammals along the coast. Seasonal climate conditions also have their effects. During fall and winter mammals may frequent the coastal beaches to forage and scavenge. It is during these periods that the beach proper becomes important to the livelihood of many terrestrial mammals.

The Alaska Department of Fish and Game, 1975, has found no critical populations or abnormal occurrences among the mammals present between Icy Bay and Cape Suckling. Further, no one mammal can be said to be more important than another or detrimental, for that matter, to this section of the coastal zone.

Coastal Zone Avifauna - Though the north Gulf contains one of the largest assemblages of bird life in the world (Copper River Delta Area) and is particularly abundant in waterfowl, with wide spread occurrences of shore related cliff dwelling, and forest inhabiting birds, the region between Icy Bay and Cape Suckling is most suitable for birds utilizing wet and shrubby and forested areas. Some small isolated marshy situations however, do occur at the mouths of some of the larger rivers.

One species preferring the wet-shrubby habitats from Icy Bay to Cape Suckling is the trumpeter swan (Olor buccinator). King (1975) has located a number of this species breeding nests. The bald eagle (Haliaeetus lucocephalus) utilizes cottonwood and spruce stands along the rivers of the same area.

A host of passeriforms (perching birds) dwell in the coniferous forest, shrub thickets and alpine tundra. They include sparrows (Fringillidae), shrikes (Lariidae) and titmice (Paridae) to name a few. Spruce grouse and ptarmigans (Tetraonidae) restrict their habits to these same areas but at somewhat higher elevations.

Many dabbling ducks (Anatinae) inhabit the small marshy habitats at the mouths of rivers and include mallards, pintails, teals (Anus sp.) and shovelers (Spatula clupeata).

Some grebes (Colymbidae) and loons (Gavidae) are no doubt also present in these areas.

Food for many of these birds is obtained from aquatic habitats (marshes, tidal areas, ponds etc.) or the forests themselves.

Ducks and swans generally feed on aquatic plants and invertebrate life. Other water related birds (gulls, grebes etc.) feed on many of the small fish along the rivers mouths and nearshore waters. Passeriforms will feed mainly on terrestrial insects and seeds found in the forest and shrub thickets. Grouse and ptarmigan subsist mainly on seeds and twigs of forest and tundra vegetation.

Nesting activities generally occur in the vicinity of preferred foodstuffs. Swans nest mainly in the shrubby undergrowth of the wet lowlands while ducks remain close to wet marsh areas. Passeriforms nest in nearby conifers and shrubs located in the drier areas. Grouse and ptarmigan hollow out areas under low lying spruce trees and alpine tundra shrubs.

Coastal usage by these and other birds is both seasonal and local. During spring and fall the coastline from Icy Bay to Cape Suckling becomes part of a major corridor to this and more northern breeding areas for many migratory species of pelagics and a majority of waterfowl. During summer months, breeding is the main activity for practically all birds in the area, many of which have already been mentioned. The winter months are the most inactive with only a few species of waterfowl present. However, some passeriforms, raptors and grouse are year-round residents.

Of all the areas utilized by birds in this section of the north Gulf during any one season the most important is the land area and adjacent river mouths. This area provides feeding, nesting and sheltering areas during many months of the year and more important it lies directly beneath the flyway for a majority of the migrating bird populus. Thus, it also provides a resting and staging area for many waterfowl flying to and from breeding areas north along the coast and inland.

DISCUSSION AND CONCLUSION

Analysis of literature concerned with the north Gulf, its nearshore waters, and coastline showed: 1) the effects of physical parameters on plant/animal distributions within the coastal zone 2) a dependency among organisms within the coastal zone from a food web standpoint, 3) varying physical/biological relationships occurring along the land/sea interface in the area defined as the coastal zone, and 4) that portion of the coastal zone where an interruption would most likely affect the majority of environmental/biological systems occurring along the north Gulf coast.

Climatic as well as physical (mountains, sediments, wetlands, glaciers etc.) parameters have combined to form a unique environment along the north Gulf coastal zone. There the landscape has been sculptured into stretches of sandy beach backed by expanses of low-wetlands and mountain ranges. Intertidal and subtidal areas are sandy with varying mud components. As a result of these factors, the distributions of plant and thus animal life have been affected. For example, moose are concentrated around Bering Glacier and the majority of marine invertebrates are non-attaching.

From this pattern of plant and animal life a food web characteristic to this section of the coastal zone can be drawn. Solar energy of the marine environments stored as organic carbon in plankton finds its way through a network of predator-prey relations until it is finally brought to the land-sea interface in the form of fish, and a myriad of annelids, crustaceans and bivalves (primarily anadromous fish, polychaetes, shrimps and clams). Solar energy of the terrestrial environment is also stored as organic carbon, but this time in terrestrial plants and arthropods (especially insects). It is brought to the land-sea interface by water related birds and anadromous fish (primarily waterfowl, some shore related birds, and salmonid fish).

The transfer of these energies is essentially in a landward direction, is linked most strongly by the various coastal and anadromous fish and is initiated by their habits and food relations with birds and some mammals.

Coupled with this energy pathway are various relations between animals and the physical landscape of the coastal zone. Though many species of animal life are known to utilize the area only a few are unique or present in notable numbers to warrant recognition.

Icy Bay has of late been recognized by Calkins and Pitcher (1975) as one of the major areas of concentration of harbor seals (Phoca vitulina) in Alaska. There the bay is rather large (approximately 8 kilometers) as well as sheltered. Ice pans calving off Guyot Glacier, are frequently afloat. These factors in combination provide prime pupping habitat for this species.

Concentrations along the coast from Icy Bay to Cape Suckling are less spectacular. There, numbers in the several hundreds occur at the White, Tsu and Seal River mouths. The turbidity of these rivers and Icy Bay apparently has no effect on the activity of these mammals.

Other than harbor seals, this section of the coastal zone does not appear to be critical to other marine mammals (sea lions, sea otters etc.) since their numbers are either insignificant, or they do not reside for any length of time in the area.

Avifauna researchers (ADF&G, 1975) studying the region from Icy Bay to Cape Suckling have no estimates on seabird concentration within the confines of Icy Bay, however, scattered numbers of cliff-dwelling birds no doubt inhabit the western edge of the bay as the banks there become rather steep.

Other than this incidence, no notable assemblage of bird-life is encountered until in the area of the Bering Glacier and then the concentration is not recognized so much for its size as it is for its tenents. Apparently the region is an extension of the Copper River breeding area (the largest northerly concentration) of the trumpeter swan (Olor buccinetor) (Dan Timm, personal communication, 1975).

Although few significant assemblages of a specific bird species (except trumpeter swans) occurs in this section of the coastal zone, the region as a whole is considered

an important segment of one of the major flyways for birds migrating further up the coast and inland.

With respect to the fish (includes marine, freshwater and anadromous) the coastal zone supports a wide range of species with the coho salmon (Oncorhynchus kisutch) the most widespread. This species is a rather strong swimmer and probably has little trouble spawning in the many swiftly flowing streams found along this section of the north Gulf - thus its relatively high numbers. This species is present in almost every stream and becomes a major nutrient/energy link to the land when preyed on by bears or consumed by carrion feeding birds (eagles, ravens etc.).

It should be noted that Oncorhynchus kisutch is of commercial interest and species of lesser interest (sculpins, sticklebacks, eulachon, herring etc.) are not equally surveyed except for determining their occurrence. Although currently not of commercial importance many of these "lesser" species comprise an additional link in the coastal zone food web, since they represent potential transfers of energy from the invertebrate faunas (copepods, insects etc.) still lower in the chain.

There appears to be only one significantly large concentration of a commercially important invertebrate species between Icy Bay and Cape Suckling, namely the weathervane scallop (Patinopecten caurinus). This concentration is peculiar to the area between Icy Bay and Cape Suckling and the species occurs in other areas of the north Gulf only to a lesser extent. Though other accumulations of invertebrates (clams, worms, insects, crabs, zooplankton etc.) in this section of the coastal zone are either commercially insignificant or occur in numbers which would not indicate that Icy Bay to Cape Suckling is critical habitat for them it is felt that they play a significant role in the coastal zone food web as many are primary (phytoplankton) and secondary (zooplankton) producers.

Alaska Department of Fish and Game (1975) has found no unexpected surprises among the concentrations and overall distributions of terrestrial mammals in this section of the north Gulf. However, not as to belabor this point, it is felt that each and every

species, however minor, has its role in the maintenance of energy flow through the coastal zone.

From the foregoing text description and the above discussion, it should be evident that land-sea interactions, both physically and biologically reach their maximum within the zone of direct influence. It is this zone which reflects the highest land-sea physical interactions and use by both marine and terrestrial fauna.

The zone of direct influence then, should be considered the most important segment of the coastal zone between Icy and Cape Suckling. For it is the main point of energy transfer in land-sea interactions. From a food web standpoint, if any one factor within the zone is stressed it should be the fish and invertebrate faunas. They act as a nutrient/energy resevoir for many water related birds and marine mammals, and those passing through provide seasonal food for certain terrestrial species. They are in general the main link in the transfer of energy between land and sea, thus contributing significantly to the biological communities of the north Gulf coastal zone between Icy Bay and Cape Suckling.

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